SPECIFIED GAS EMITTERS REGULATION

QUANTIFICATION PROTOCOL FOR LANDFILL GAS CAPTURE AND COMBUSTION

SEPTEMBER 2007

Version 1

Alberta
ENVIRONMENT

LBERTANS CLIMATE CHANGE

Disclaimer:

The information provided in this document is intended as guidance only and is subject to revisions as learnings and new information comes forward as part of a commitment to continuous improvement. This document is not a substitute for the law. Please consult the *Specified Gas Emitters Regulation* and the legislation for all purposes of interpreting and applying the law. In the event that there is a difference between this document and the *Specified Gas Emitters Regulation* or legislation, the *Specified Gas Emitters Regulation* or the legislation prevail.

Acknowledgements:

This protocol is largely based on the *Draft Quantification Protocol for Landfill Gas Capture and Combustion* dated April 11, 2006. This document was prepared by Enviro-Access Inc. for submission to Environment Canada. This document represents an abridged, re-formatted and amended version of the referenced work. Therefore, the seed document remains as a source of additional detail on any of the technical elements of the protocol.

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ISBN: 978-0-7785-7234-3 (Printed)
ISBN: 978-0-7785-7235-0 (On-line)

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1.0 Project and Methodology Scope and Description

This quantification protocol is written for the landfill operator or a landfill gas project developer. Some familiarity with, or general understanding of, the operation of a landfill and the collection and combustion of landfill gas (LFG) is expected.

The opportunity for generating carbon offsets with this protocol arises mainly from indirect GHG emission reductions through the use of captured methane from the landfill to offset non-renewable electricity production and/or avoid methane emissions from destruction of methane.

1.1 Protocol Scope and Description

LFG is passively emitted due to the anaerobic decomposition of the organic components within the landfill. As the carbon dioxide component of the LFG is biogenic, this protocol is focused on the methane component. Landfill gas collection and combustion reduces the quantity of methane emissions released to the atmosphere from the landfill. The combustion of the methane component of the landfill gas results in emissions of biogenic carbon dioxide thus achieving a reduction in man-made GHG emissions. In addition, the generation of heat, power and electricity will offset other sources, which can include the combustion of fossil fuels.

The use of LFG under controlled conditions may include:

- Combustion for the generation of heat and/or power;
- Combustion for the generation of electricity;
- Destruction during controlled flaring; and/or
- Pipeline distribution to an end-user for combustion purposes.

Combustion of the LFG may occur on- or off-site, and must be occur under controlled conditions. **FIGURE 1.1** offers a process flow diagram for a typical project.

This protocol serves as a generic ‘recipe’ for project developers to follow in order to meet the measurement, monitoring and GHG quantification requirements for reductions due to LFG capture and usage under controlled conditions.

Protocol Approach:
The baseline condition represents the emissions of GHGs from waste decomposition in a landfill that would have been released to the atmosphere without LFG capture and combustion under controlled conditions. The baseline condition is thus dependent on the <u>volume</u> of LFG captured and combusted, and <u>not on</u> the size, waste composition, operational method or other characteristics of the project landfill. This allows the protocol to be applied across a variety of landfills with an equivalent result. **FIGURE 1.2** offers a process flow diagram for a typical baseline configuration.

FIGURE 1.1: Process Flow Diagram for Project Condition

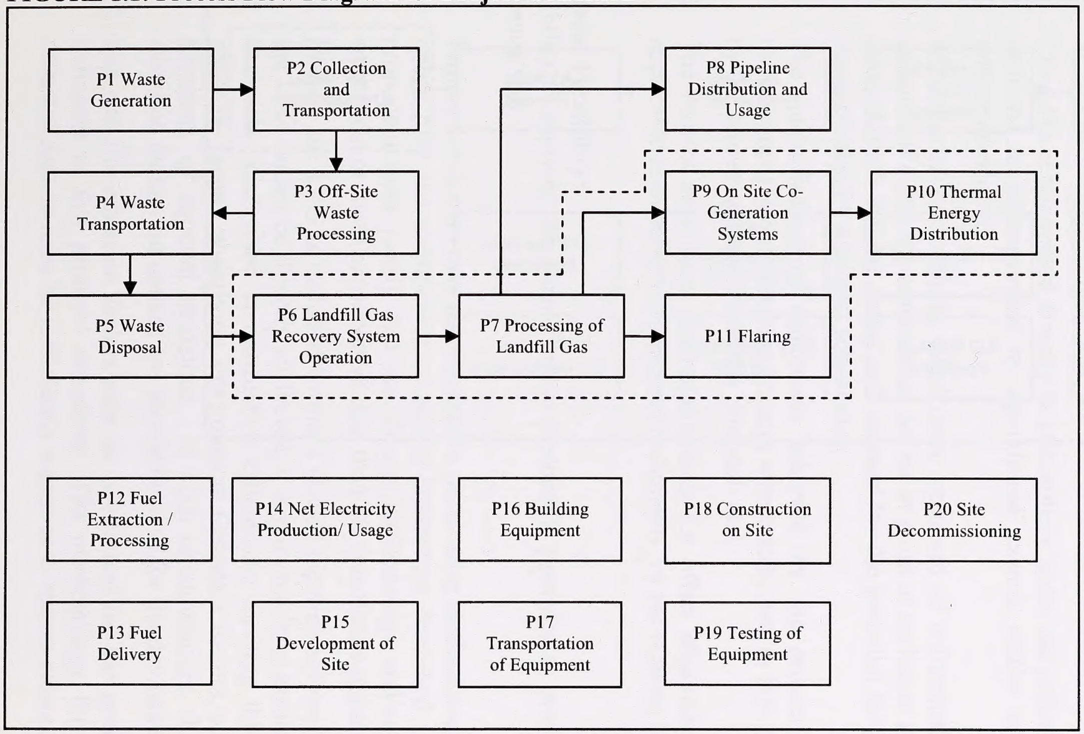
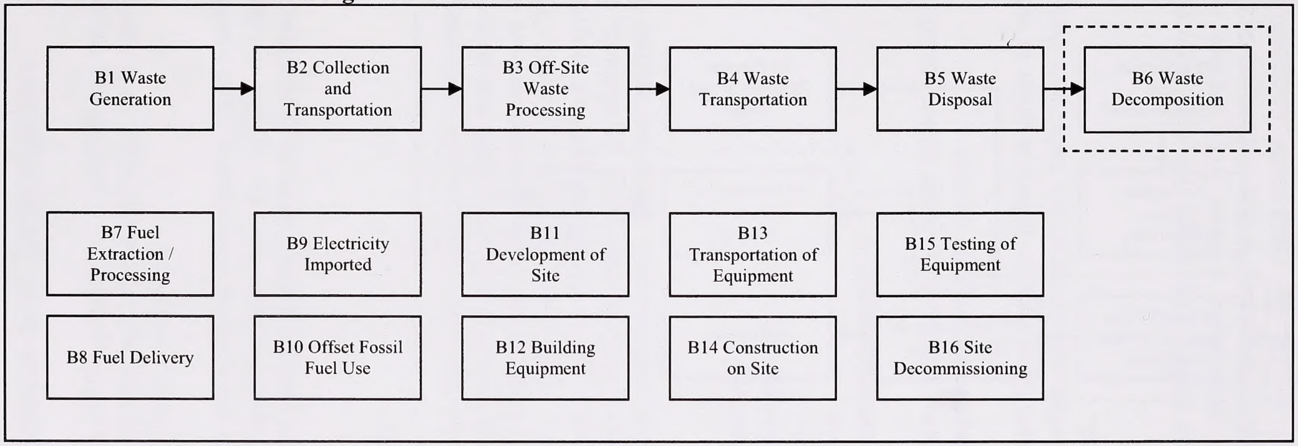


FIGURE 1.2: Process Flow Diagram for Baseline Condition



This protocol does not attempt to estimate or quantify the total GHG emissions from a landfill. The GHG reduction calculation is based on the measurement of the *volume of LFG collected and the assumption that all of the LFG collected would have been released in the absence of an LFG collection system.* Thus the calculation of the total volume of methane generated in the landfill, using modeling or other calculation methods, is not required under this protocol.

Protocol Applicability:
To demonstrate that a project meets the requirements under this protocol, the project developer must supply sufficient evidence to demonstrate that:

1. The combustion is carried out under controlled conditions as demonstrated by a description of the LFG end use and specifications of the combustion device in use;
2. The LFG is not vented directly to atmosphere under the project condition once it is gathered as demonstrated by operational records and/or an affirmation by the project developer;
3. Metering of gas volumes takes place upstream of collection within a reasonable distance of either the combustion device or point of inclusion in the off-site pipeline network such that the meter will account for the potential for fugitive emissions as demonstrated by a project schematics;
4. The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol; and,
5. The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System.

Protocol Flexibility:
Flexibility in applying the quantification protocol is provided to project developers in the following ways:

1. Project developers may use alternative monitoring methodologies and/or equipment rather than the methodologies and/or equipment described in this protocol. The proponent must justify that the chosen methodology and/or equipment provides equivalent or more conservative data than the specified equipment;
2. [Where the LFG is included within a shared pipeline network, and the end-use of the LFG cannot be directly attributed, it is reasonable to assume that the end use is complete combustion at destruction efficiencies meeting the assumptions of the emission factors underlying Environment Canada's factors, as listed in the annual inventory of national emissions. In such circumstances, the most conservative emission factors for natural gas should be used for the downstream use of the LFG];
3. Site specific emission factors may be substituted for the generic emission factors indicated in this protocol document. The methodology for generation of these emission factors must be sufficiently robust as to ensure reasonable accuracy;

4. [This protocol may be used to quantify emission reductions from an upgrade of an open flare to a controlled combustion device. For the purposes of this protocol, the efficiency of an open flare is assumed to be 25%. As such, the baseline condition for conversion from an open flare to controlled combustion would be the same as conversion from no flare to controlled combustion with a corresponding discount of 25% applied to all volumes of LFG combusted or included into the pipeline]; and
5. Project developers may use a site-specific flare efficiency for an open flare, provided there is sufficient data to support the efficiency chosen

If applicable, the proponent must indicate and justify why flexibility provisions have been used.

1.2 Glossary of New Terms

Functional Equivalence	The Project and the Baseline should provide the same function and inputs and outputs (i.e. metered landfill gas). This type of comparison requires a common metric or unit of measurement for comparison between the Project and Baseline activity (refer to the Project Guidance Document for the Alberta Offset System for more information).
Bioreactor Landfill:	A landfill cell that is specifically engineered to enhance the decomposition of wastes through careful manipulation of site conditions.
Controlled Conditions:	Specific conditions in terms of temperature, residence time and air intake taking place in an enclosed space to optimize the combustion of methane.
Landfill:	A defined area of land or excavation that receives or has previously received waste that may include household waste, commercial solid waste, non hazardous sludge and industrial solid waste.
Landfill Gas:	Gas resulting from the decomposition of wastes placed in a landfill typically comprised primarily of methane, carbon dioxide and other trace compounds.
Landfill Gas Project:	Installation of infrastructure that in operating causes a decrease in GHG emissions through combustion of the methane component of LFG.

2.0 Quantification Development and Justification

The following sections outline the quantification development and justification.

2.1 Identification of Sources and Sinks (SS's) for the Project

SS's were identified for the project by reviewing the seed documents and relevant process flow diagram developed by Enviro-Access Inc. for Environment Canada. This process confirmed that the SS's in the process flow diagrams covered the full scope of eligible project activities under the protocol.

Based on the process flow diagrams provided in **FIGURE 1.1**, the project SS's were organized into life cycle categories in **FIGURE 2.1**. Descriptions of each of the SS's and their classification as controlled, related or affected are provided in **TABLE 2.1.**

FIGURE 2.1: Project Element Life Cycle Chart

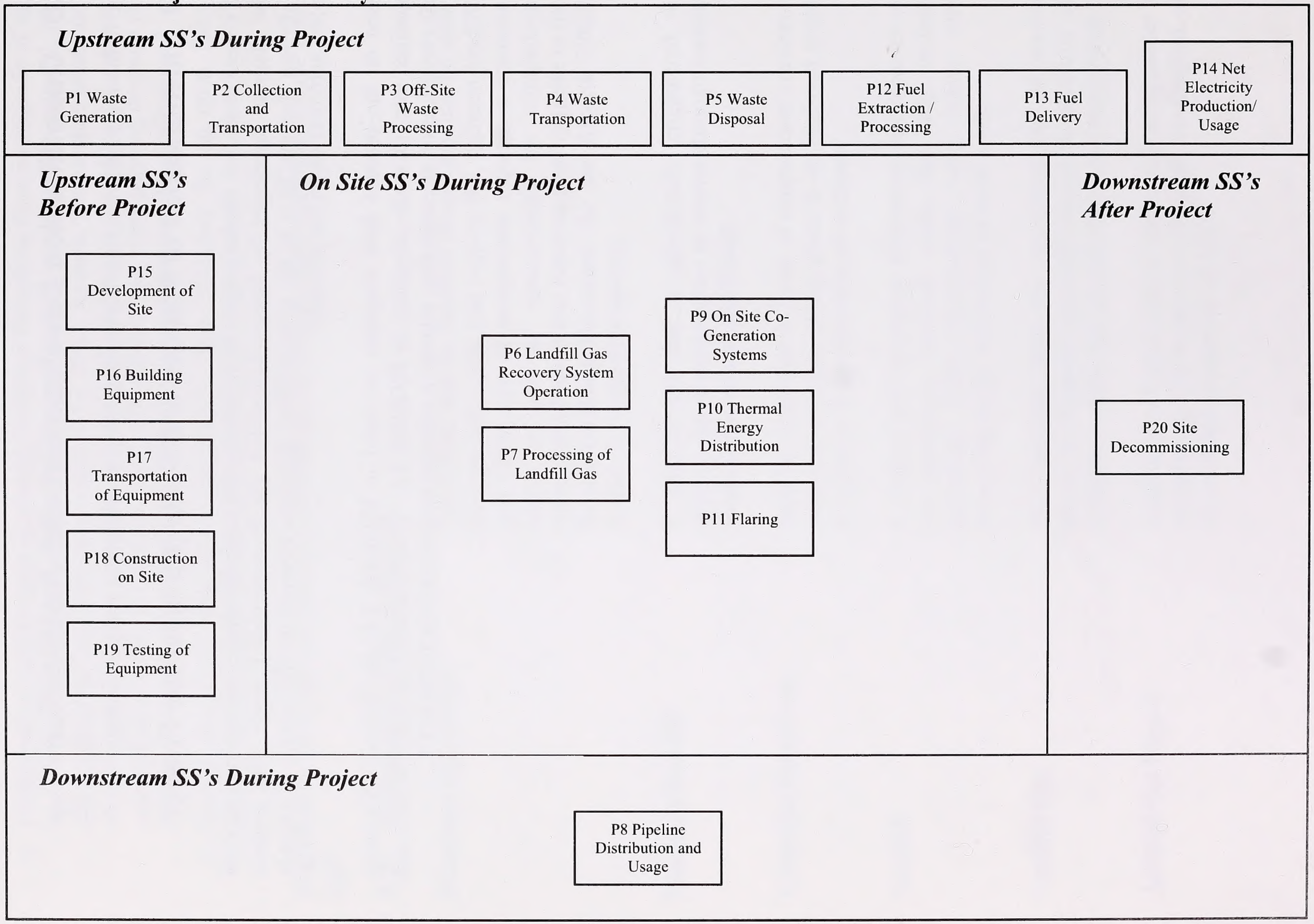


TABLE 2.1: Project SS's

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SS's during Project Operation		
P1Waste Generation	Streams of solid waste are produced in a number ways, depending on the source of these residues. Quantities for each of the energy inputs related to the generation of the waste streams would be contemplated to evaluate functional equivalence with the baseline condition.	Related
P2 Collection and Transportation	Solid waste may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
P3 Off-Site Waste Processing	Solid waste may be processed using a series of mechanical processes, heavy equipment and conveyors. This equipment would be fuelled by diesel, gasoline, or natural gas resulting in GHG emissions, or electricity. Quantities and types for each of the energy inputs would be tracked.	Related
P4 Waste Transportation	Organic residues may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
P5 Waste Processing and Disposal	Waste may be handled at a disposal site by transferring the waste from the transportation container, spreading, burying, processing, otherwise dealing with the waste using a combination of loaders, conveyors and other mechanized devices. This equipment would be fuelled by diesel, gasoline or natural gas, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities and types for each of the energy inputs may need to be tracked.	Controlled
P12 Fuel Extraction and Processing	Each of the fuels used throughout the on-site component of the project will need to sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site SS's are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related
P13 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's and there is no other delivery.	Related
P14 Net Electricity Production/ Usage	Electricity may be required for operating the facility. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. Quantity and source of power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Related

Onsite SS's during Project Operation		
P6 Landfill Gas Recovery System Operation	Landfill gas recovery systems require compressors and other equipment for the gathering and distribution of the gas at the project facility. This equipment may be fuelled by diesel, gasoline or natural gas, resulting in GHG emissions. Other fuels, such as landfill gas, may also be used in some rare cases. Quantities and types for each of the energy inputs may need to be tracked.	Controlled
P7 Processing of Landfill Gas	Landfill gas will likely have a higher concentration of carbon dioxide and other impurities than may be acceptable for the any number of uses. Mechanical equipment may be required to treat the landfill gas in order meet the required specifications. This may require several energy inputs such as natural gas and diesel. Quantities and types for each of the energy inputs would be tracked.	Controlled
P9 On Site Co-Generation Systems	On site co-generation systems may be included at the project site. This generation could require the combustion of landfill gas, and may be supplemented by fossil fuels precipitating greenhouse gas emissions. Volumes and types of fuels are the important characteristics to be tracked.	Controlled
P10 Thermal Energy Distribution	Thermal energy may need to be distributed around or from the project site. This may require compression or other mechanical processes and includes any recirculation functions. The energy inputs related to this function would need to be tracked.	Controlled
P11 Flaring	Flaring of the landfill gas may be required during upset conditions or during maintenance. Emissions of greenhouse gases would be contributed from the combustion of the LFG as well as from any natural gas used in flaring to ensure more complete combustion. Quantities of LFG being flared and quantities of any pilot fuels or supplemental fuels would need to be tracked.	Controlled
Downstream SS's during Project Operation		
P8 Pipeline Distribution and Usage	Landfill gas may be input to a pipeline system and distributed to customers at another point on the distribution system. This gas may be further processed or consumed by the consumer. The most reasonable fate would be combustion in a controlled manner. This quantity of landfill gas input to the pipeline system would need to be tracked.	Related
Other		
P15 Development of Site	The site may need to be developed. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer etc. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas, storm water drainage, offices, vent stacks, firefighting water storage lagoons, etc., as well as structures to enclose, support and house the equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
P16 Building Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, system control and safety systems. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related

P17 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site, will all need to be delivered to the site. Transportation may be completed by train, truck, by some combination, or even by courier. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
P18 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related
P19 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test anaerobic digestion fuels or fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
P20 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

2.2 Identification of Baseline

The baseline condition for projects applying this protocol is defined as the volume of methane captured that would otherwise have been released to the atmosphere, less the volume of methane that would have been captured under any other existing regulations. The baseline scenario for conversion from an open flare to controlled combustion is considered to be the same as the baseline scenario for conversion from no flare to controlled combustion. The baseline is thus project-specific.

The approach to quantifying the baseline will be calculation based as there are suitable data available for the applicable baseline condition that can provide reasonable certainty. The baseline scenario for this protocol is dynamic as the volume of methane would be expected to change materially relative to the age of the landfill, and the baseline condition may vary from project to project.

The baseline condition is defined, including the relevant SS's and processes, as shown in **FIGURE 1.2**. More detail on each of these SS's is provided in Section 2.3, below.

2.3 Identification of SS's for the Baseline

Based on the process flow diagrams provided in **FIGURE 1.2**, the project SS's were organized into life cycle categories in **FIGURE 2.2**. Descriptions of each of the SS's and their classification as either 'controlled', 'related' or 'affected' is provided in **TABLE 2.2.**

FIGURE 2.2: Baseline Element Life Cycle Chart

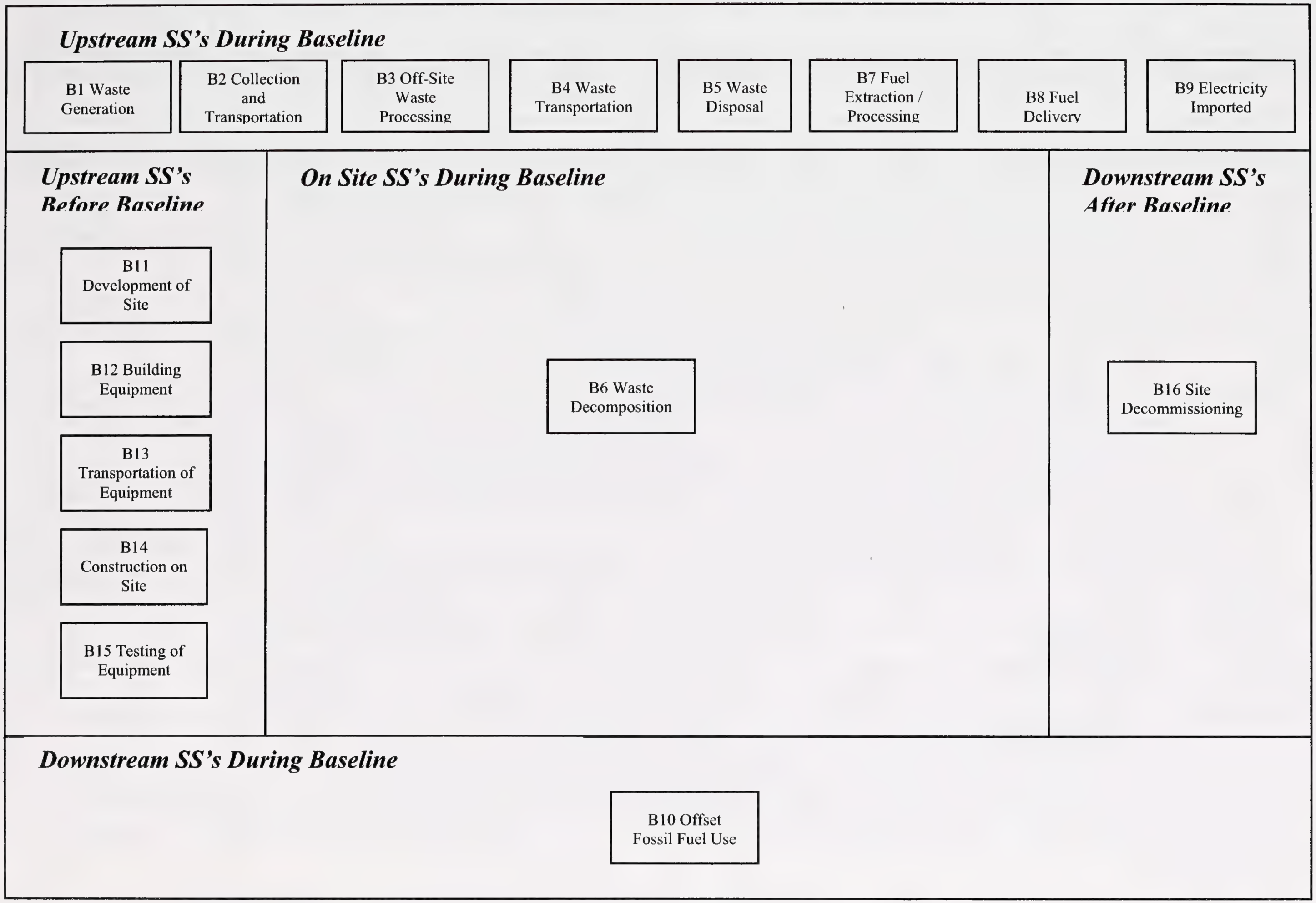


TABLE 2.2: Baseline SS's

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SS's during Baseline Operation		
B1Waste Generation	Streams of solid waste are produced in a number ways, depending on the source of these residues. Quantities for each of the energy inputs related to the generation of the waste streams would be contemplated to evaluate functional equivalence with the baseline condition.	Related
B2 Collection and Transportation	Solid waste may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
B3 Off-Site Waste Processing	Solid waste may be processed using a series of mechanical processes, heavy equipment and conveyors. This equipment would be fuelled by diesel, gasoline, or natural gas resulting in GHG emissions, or electricity. Quantities and types for each of the energy inputs would be tracked.	Related
B4 Waste Transportation	Organic residues may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
B5 Waste Disposal	Waste may be handled at a disposal site by transferring the waste from the transportation container, spreading, burying, processing, otherwise dealing with the waste using a combination of loaders, conveyors and other mechanized devices. This equipment would be fuelled by diesel, gasoline or natural gas, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities and types for each of the energy inputs may need to be tracked.	Controlled
B7 Fuel Extraction and Processing	Each of the fuels that may be offset by the consumption of the landfill gas used off-site would need to sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site SS's are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related
B8 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's and there is no other delivery.	Related
B9 Electricity Imported	Electricity may be produced off-site to cover the electricity demand not being produced by the landfill gas recovery facility. This electricity will be produced at an emissions intensity as deemed appropriate. Measurement of the gross quantity of electricity produced by the facility will need to be tracked to quantify this SS.	Related

Onsite SS's during Baseline Operation		
B6 Waste Decomposition	Waste may decompose in the disposal facility resulting in the production of methane. Disposal site characteristics and mass disposed of at each site may need to be tracked.	Controlled
Downstream SS's during Baseline Operation		
B10 Offset Fossil Fuel Use	Fossil fuel use may occur off-site to cover the energy that may be supplied by the landfill gas exported from the landfill gas recovery facility. Volumes and types of fuels are the important characteristics to be tracked.	Related
Other		
B11 Development of Site	The site of the material processing and disposal facilities may need to be developed. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer etc. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas, storm water drainage, offices, vent stacks, firefighting water storage lagoons, etc., as well as structures to enclose, support and house the equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
B12 Building Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, system control and safety systems. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related
B13 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site, will all need to be delivered to the site. Transportation may be completed by train, truck, by some combination, or even by courier. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
B14 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related
B15 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test anaerobic digestion fuels or fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
B16 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

2.4 Selection of Relevant Project and Baseline SS's

Each of the SS's from the project and baseline condition were compared and evaluated as to their relevancy using the guidance provided in Annex VI of the "Guide to Quantification Methodologies and Protocols: Draft", dated March 2006 (Environment Canada). The justification for the exclusion or conditions upon which SS's may be excluded is provided in **TABLE 2.3** below. All other SS's listed previously are included.

TABLE 2.3: Comparison of SS's

1. Identified SS	2. Baseline (C, R, A)	3. Project (C, R, A)	4. Include or Exclude from Quantification	5. Justification for Exclusion
Upstream SS's				
P1Waste Generation	N/A	Related	Exclude	Excluded as the generation of solid waste are not impacted by the implementation of the project and as such the baseline and project conditions will be functionally equivalent.
B1Waste Generation	Related	N/A	Exclude	
P2 Collection and Transportation	N/A	Related	Exclude	Excluded as the emissions from transportation are negligible and likely functionally equivalent to the baseline scenario.
B2 Collection and Transportation	Related	N/A	Exclude	
P3 Off-Site Waste Processing	N/A	Related	Exclude	Excluded as the off-site processing of solid waste is not impacted by the implementation of the project and as such the baseline and project conditions will be functionally equivalent.
B3 Off-Site Waste Processing	Related	N/A	Exclude	
P4 Waste Transportation	N/A	Related	Exclude	Excluded as the emissions from transportation are negligible and likely functionally equivalent to the baseline scenario.
B4 Waste Transportation	Related	N/A	Exclude	
P5 Waste Disposal	N/A	Controlled	Exclude	Excluded as the disposal of waste at the site is not impacted by the implementation of the project and as such the baseline and project conditions will be functionally equivalent.
B5 Waste Disposal	Controlled	N/A	Exclude	
P12 Fuel Extraction and Processing	N/A	Related	Include	N/A
B7 Fuel Extraction and Processing	Related	N/A	Include	N/A
P13 Fuel Delivery	N/A	Related	Exclude	Excluded as the emissions from transportation are negligible and likely greater under the baseline condition.
B8 Fuel Delivery	Related	N/A	Exclude	
P14 Net Electricity Production/ Usage	N/A	Related	Exclude	Excluded as these SS's are not relevant to the project as the emissions from these practises are covered under proposed greenhouse gas regulations.
B9 Electricity Imported	Related	N/A	Include	N/A
Onsite SS's				
P6 Landfill Gas Recovery System Operation	N/A	Controlled	Include	N/A
P7 Processing of Landfill Gas	N/A	Controlled	Include	N/A

P9 On Site Co-Generation Systems	N/A	Controlled	Include	N/A
P10 Thermal Energy Distribution	N/A	Controlled	Include	N/A
P11 Flaring	N/A	Controlled	Include	N/A. Pilot fuel for flare stack is excluded as this has been shown to be immaterial.
B6 Waste Decomposition	Controlled	N/A	Include	N/A
Downstream SS's				
P8 Pipeline Distribution and Usage	N/A	Related	Include	N/A
B10 Offset Fossil Fuel Use	Related	N/A	Include	N/A
Other				
P15 Development of Site	N/A	Related	Exclude	Emissions from site development are not material given the long project life, and the minimal site development typically required.
B11 Development of Site	Related	N/A	Exclude	Emissions from site development are not material for the baseline condition given the minimal site development typically required.
P16 Building Equipment	N/A	Related	Exclude	Emissions from building equipment are not material given the long project life, and the minimal building equipment typically required.
B12 Building Equipment	Related	N/A	Exclude	Emissions from building equipment are not material for the baseline condition given the minimal building equipment typically required.
P17 Transportation of Equipment	N/A	Related	Exclude	Emissions from transportation of equipment are not material given the long project life, and the minimal transportation of equipment typically required.
B13 Transportation of Equipment	Related	N/A	Exclude	Emissions from transportation of equipment are not material for the baseline condition given the minimal transportation of equipment typically required.
P18 Construction on Site	N/A	Related	Exclude	Emissions from construction on site are not material given the long project life, and the minimal construction on site typically required.

B14 Construction on Site	Related	N/A	Exclude	Emissions from construction on site are not material for the baseline condition given the minimal construction on site typically required.
P19 Testing of Equipment	N/A	Related	Exclude	Emissions from testing of equipment are not material given the long project life, and the minimal testing of equipment typically required.
B15 Testing of Equipment	Related	N/A	Exclude	Emissions from testing of equipment are not material for the baseline condition given the minimal testing of equipment typically required.
P20 Site Decommissioning	N/A	Related	Exclude	Emissions from decommissioning are not material given the long project life, and the minimal decommissioning typically required.
B16 Site Decommissioning	Related	N/A	Exclude	Emissions from decommissioning are not material for the baseline condition given the minimal decommissioning typically required.

2.5 Quantification of Reductions, Removals and Reversals of Relevant SS's

2.5.1 QUANTIFICATION APPROACHES

Quantification of the reductions, removals and reversals of relevant SS's for each of the greenhouse gases will be completed using the methodologies outlined in **TABLE 2.4**, below. A listing of relevant emission factors is provided in **Appendix A**. These calculation methodologies serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Electricity Production}} + \text{Emissions}_{\text{Waste Decomposition}} + \text{Emissions}_{\text{Offset Fossil Fuel Use}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Recovery System}} + \text{Emissions}_{\text{Processing of Landfill Gas}} + \text{Emissions}_{\text{Onsite Co-generation}} + \text{Emissions}_{\text{Thermal Energy}} + \text{Emissions}_{\text{Flaring}} + \text{Emissions}_{\text{Pipeline distribution}}$$

Where:

$\text{Emissions}_{\text{Baseline}}$ = sum of the emissions under the baseline condition.

$\text{Emissions}_{\text{Fuel Extraction / Processing}}$ = emissions under SS B7 Fuel Extraction and Processing

$\text{Emissions}_{\text{Electricity Production}}$ = emissions under SS B9 Electricity Imported

$\text{Emissions}_{\text{Waste Decomposition}}$ = emissions under SS B6 Waste Decomposition

$\text{Emissions}_{\text{Offset Fossil Fuel Use}}$ = emissions under SS B10 Offset Fossil Fuel Use

$\text{Emissions}_{\text{Project}}$ = sum of the emissions under the project condition.

$\text{Emissions}_{\text{Fuel Extraction / Processing}}$ = emissions under SS P12 Fuel Extraction and Processing

$\text{Emissions}_{\text{Recovery System}}$ = emissions under SS P6 Landfill Gas Recovery System Operation

$\text{Emissions}_{\text{Processing of Landfill Gas}}$ = emissions under SS P7 Processing of Landfill Gas

$\text{Emissions}_{\text{Onsite Co-generation}}$ = emissions under SS P9 Onsite Cogeneration Systems

$\text{Emissions}_{\text{Thermal Energy}}$ = emissions under SS P10 Thermal Energy Distribution

$\text{Emissions}_{\text{Flaring}}$ = emissions under SS P11 Flaring

$\text{Emissions}_{\text{Pipeline distribution}}$ = emissions under SS P8 Pipeline Distribution and Usage

TABLE 2.4: Quantification Procedures

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
Project SS's						
P12 Fuel Extraction and Processing	$Emissions_{Fuel\ Extraction\ /\ Processing} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$					
	$Emissions_{Fuel\ Extraction\ /\ Processing}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Fossil Fuel Combusted for P6 to P11 / Vol_{Fuel}	m^3	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Fuel Including Production and Processing / EF $Fuel_{CO2}$	kg CO_2 per m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Fuel Including Production and Processing / EF $Fuel_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Fuel Including Production and Processing / EF $Fuel_{N2O}$	kg N2O per m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P6 Landfill Gas Recovery	$Emissions_{LFG\ System} = (Vol.\ LFG\ Consumed * \%\ CH_4 * EF\ LFG_{CH4})$; $(Vol.\ LFG\ Consumed * \%\ CH_4 * EF\ LFG_{N2O})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$					

System Operation	Emissions $_{LFG\ System}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Landfill Gas Consumed / Vol. LFG Consumed	m^3	Measured	Direct metering of volume of LFG being flared.	Continuous metering	Direct metering is standard practise. Frequency of metering is highest level possible.
	Methane Composition in Landfill Gas / % CH_4	-	Measured	Direct measurement.	Daily sampling averaged monthly on a volumetric basis	LFG composition should remain relatively stable during steady-state operation.
	CH_4 Emissions Factor for Landfill Gas / EF LFG $_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on Industrial emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Landfill Gas / EF LFG $_{N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on Industrial emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Volume of Each Type of Fuel used / Vol Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.

	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P7 Processing of Landfill Gas	Emissions $_{Process\ LFG}$ = (Vol. LFG Consumed * % CH_4 * EF LFG $_{CH4}$) ; (Vol. LFG Flared * % CH_4 * EF LFG $_{N2O}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)					
	Emissions $_{Process\ LFG}$	kg of CO_2; CH_4; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Landfill Gas Consumed / Vol. LFG Consumed	m^3	Measured	Direct metering of volume of LFG being consumed.	Continuous metering.	Direct metering is standard practise. Frequency of metering is highest level possible.
	Methane Composition in LFG / % CH_4	-	Measured	Direct measurement.	Daily sampling averaged monthly on a volumetric basis	LFG composition should remain relatively stable during steady-state operation.

	CH_4 Emissions Factor for Landfill Gas / EF LFG $_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on Industrial emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Landfill Gas / EF LFG $_{N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on Industrial emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Volume of Each Type of Fuel Used/ Vol Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

P8 Pipeline Distribution and Usage	$Emissions_{Pipeline} = (Vol.\ LFG\ Consumed * \%\ CH_4 * EF\ LFG_{CH4})$; $(Vol.\ LFG\ Consumed * \%\ CH_4 * EF\ LFG_{N2O})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$					
	$Emissions_{Pipeline}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Landfill Gas Consumed / Vol. LFG Consumed	m^3	Measured	Direct metering of volume of LFG being consumed.	Continuous metering.	Direct metering is standard practise. Frequency of metering is highest level possible.
	Methane Composition in LFG / % CH_4	-	Measured	Direct measurement.	Daily sampling averaged monthly on a volumetric basis	LFG composition should remain relatively stable during steady-state operation.
	CH_4 Emissions Factor for Landfill Gas / EF LFG_{CH4}	kg CH_4 per m^3	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on the most reasonable and conservative emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Landfill Gas / EF LFG_{N2O}	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on the most reasonable and conservative emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

	Volume of Each Type of Fuel used / Vol Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P9 On Site Co-Generation Systems	Emissions $_{Co\text{-}Gen}$ = (Vol. LFG Consumed * % CH_4 * EF LFG $_{CH4}$) ; (Vol. LFG Consumed * % CH_4 * EF LFG $_{N2O}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)					
	Emissions $_{Co\text{-}Gen}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Landfill Gas Consumed / Vol. LFG Consumed	m^3	Measured	Direct metering of volume of LFG being consumed.	Continuous metering.	Direct metering is standard practise. Frequency of metering is highest level possible.
	Methane Composition in LFG / % CH_4	-	Measured	Direct measurement.	Daily sampling averaged monthly on a volumetric basis	LFG composition should remain relatively stable during steady-state operation.

	CH_4 Emissions Factor for Landfill Gas / EF LFG $_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Landfill Gas / EF LFG $_{N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Volume of Each Type of Fuel used / Vol Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\,CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\,CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\,N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

P10 Thermal Energy Distribution	Emissions $_{Heat\ Dist}$ = (Vol. LFG Consumed * % CH_4 * EF LFG $_{CH4}$) ; (Vol. LFG Consumed * % CH_4 * EF LFG $_{N2O}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)					
	Emissions $_{Heat\ Dist}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Landfill Gas Consumed / Vol. LFG Consumed	m^3	Measured	Direct metering of volume of LFG being consumed.	Continuous metering.	Direct metering is standard practise. Frequency of metering is highest level possible.
	Methane Composition in LFG / % CH_4	-	Measured	Direct measurement.	Daily sampling averaged monthly on a volumetric basis	LFG composition should remain relatively stable during steady-state operation.
	CH_4 Emissions Factor for Landfill Gas / EF LFG $_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on Industrial emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Landfill Gas / EF LFG $_{N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on Industrial emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Volume of Each Type of Fuel used / Vol Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.

	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P11 Flaring	Emissions $_{Flaring}$ = (Vol. LFG Flared * % CH_4 * EF LFG $_{CH4}$) ; (Vol. LFG Flared * % CH_4 * EF LFG $_{N2O}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)					
	Emissions $_{Flaring}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Landfill Gas Flared / Vol. LFG Flared	m^3	Measured	Direct metering of volume of LFG being flared.	Continuous metering.	Direct metering is standard practise. Frequency of metering is highest level possible.
	Methane Composition in LFG / % CH_4	-	Measured	Direct measurement.	Daily sampling averaged monthly on a volumetric basis	LFG composition should remain relatively stable during steady-state operation.

	CH_4 Emissions Factor for Landfill Gas / EF LFG $_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on Industrial emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Landfill Gas / EF LFG $_{N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents. In the absence of LFG data, rely on Industrial emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the LFG.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Volume of Each Type of Fuel used to Supplement Flare / Vol Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

Baseline SS's						
B7 Fuel Extraction and Processing	Emissions $_{Fuel\ Extraction\ /\ Processing} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$					
	Emissions $_{Fuel\ Extraction\ /\ Processing}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Fossil Fuel Combusted for B10 / Vol Fuel	m^3	Measured	Direct metering or reconciliation of volumes transferred.	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Fuel Including Production and Processing / EF Fuel $_{CO2}$	kg CO_2 per m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Fuel Including Production and Processing / EF Fuel $_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Fuel Including Production and Processing / EF Fuel $_{N2O}$	kg N2O per m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B9 Electricity Imported	Emissions $_{Electricity}$ = Electricity * EF $_{Elec}$					
	Emissions $_{Electricity}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.

	Incremental Electricity Exported from the Site / Electricity	kWh	Measured	Direct metering.	Continuous metering	Continuous direct metering represents the industry practise and the highest level of detail.
	Emissions Factor for Electricity / EF_{Elec}	kg of CO2e per kWh	Estimated	From Alberta Environment documents.	Annual	Reference values adjusted From Alberta Environment documents.
B6 Waste Decomposition	$Emissions_{Waste\ Decomp} = Vol_{LFG\ Consumed} * \%\ CH_4 * \rho\ CH_4$					
	$Emissions_{Waste\ Decomp}$	kg of CH_4	N/A	N/A	N/A	Quantity being calculated.
	Volume of Landfill Gas Consumed / $Vol_{LFG\ Consumed}$	m^3	Measured	Direct measurement of mass of material decomposed.	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	Methane Composition in LFG / % CH_4	-	Measured	Direct measurement.	Daily sampling averaged monthly on a volumetric basis	LFG composition should remain relatively stable during steady-state operation.
	Density of Methane	kg / m^3	Constant	0.7157 at standard temperature and pressure.	Actual value	If this value is used all values must be adjusted for standard temperature and pressure.
B10 Offset Fossil Fuel Use	$Emissions_{Fuel\ Offset} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$					
	$Emissions_{Fuel\ Offset}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.

	Volume of Each Type of Fuel Offset by Landfill Gas / Vol $Fuel_i$	m^3	Measured	Direct metering or reconciliation of volumes transferred.	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Combustion of Each Type of Fuel / EF $Fuel_{i\ CO2}$	kg CO_2 per m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Combustion of Each Type of Fuel / EF $Fuel_{i\ CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Combustion of Each Type of Fuel / EF $Fuel_{i\ N2O}$	kg N2O per m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

2.5.2. Contingent Data Approaches

Contingent means for calculating or estimating the required data for the equations outlined in section 2.5.1 are summarized in **TABLE 2.5**, below.

2.6 Management of Data Quality

In general, data quality management must include sufficient data capture such that the mass and energy balances may be easily performed with the need for minimal assumptions and use of contingency procedures. The data should be of sufficient quality to fulfill the quantification requirements and be substantiated by company records for the purpose of verification.

The project proponent shall establish and apply quality management procedures to manage data and information. Written procedures should be established for each measurement task outlining responsibility, timing and record location requirements. The greater the rigour of the management system for the data, the more easily an audit will be to conduct for the project.

2.6.1 Record Keeping

Record keeping practises should include:

a. Electronic recording of values of logged primary parameters for each measurement interval;
b. Printing of monthly back-up hard copies of all logged data;
c. Written logs of operations and maintenance of the project system including notation of all shut-downs, start-ups and process adjustments;
d. Retention of copies of logs and all logged data for a period of 7 years; and
e. Keeping all records available for review by a verification body.

2.6.1 Quality Assurance/Quality Control (QA/QC)

QA/QC can also be applied to add confidence that all measurements and calculations have been made correctly. These include, but are not limited to:

a Protecting monitoring equipment (sealed meters and data loggers);
b Protecting records of monitored data (hard copy and electronic storage);
c Checking data integrity on a regular and periodic basis (manual assessment, comparing redundant metered data, and detection of outstanding data/records);
d Comparing current estimates with previous estimates as a ‘reality check’;
e Provide sufficient training to operators to perform maintenance and calibration of monitoring devices;
f Establish minimum experience and requirements for operators in charge of project and monitoring; and
g Performing recalculations to make sure no mathematical errors have been made.

TABLE 2.5: Contingent Data Collection Procedures

1.0 Project / Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Contingency Method	6. Frequency	7. Justify measurement or estimation and frequency
Project SS's						
P12 Fuel Extraction and Processing	Volume of Each Type of Fuel / Vol. Fuel $_i$	L/ m^3/ other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P6 Landfill Gas Recovery System Operation	Methane Composition in Landfill Gas / % CH_4	--	Estimated	Interpolation of previous and following measurements taken.	Daily	LFG composition should remain relatively stable during steady-state operation. Interpolating gas composition provides a reasonable estimate when the more accurate and precise method cannot be used.
	Volume of Landfill Gas Consumed / Vol. LFG Consumed	L/ m^3/ other	Estimated	Reconciliation of volume of fuel consumed within given time period based on equipment efficiency specifications and average flow rates.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Volume of Each Type of Fuel used / Vol. Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P7 Processing of Landfill Gas	Volume of Landfill Gas Consumed / Vol. LFG Consumed	m^3	Estimated	Reconciliation of volume of fuel consumed within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Methane Composition in LFG / % CH_4	-	Estimated	Interpolation of previous and following measurements taken.	Daily	LFG composition should remain relatively stable during steady-state operation. Interpolating gas composition provides a reasonable estimate when the more accurate and precise method cannot be used.

	Volume of Each Type of Fuel used / Vol. Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P8 Pipeline Distribution and Usage	Volume of Landfill Gas Consumed / Vol. LFG Consumed	m^3	Estimated	Reconciliation of volume of fuel consumed within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Methane Composition in LFG / % CH_4	-	Estimated	Interpolation of previous and following measurements taken.	Daily	LFG composition should remain relatively stable during steady-state operation. Interpolating gas composition provides a reasonable estimate when the more accurate and precise method cannot be used.
	Volume of Each Type of Fuel used / Vol. Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P9 On Site Co-Generation Systems	Volume of Landfill Gas Consumed / Vol. LFG Consumed	m^3	Estimated	Reconciliation of volume of fuel consumed within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Methane Composition in LFG / % CH_4	-	Estimated	Interpolation of previous and following measurements taken.	Daily	LFG composition should remain relatively stable during steady-state operation. Interpolating gas composition provides a reasonable estimate when the more accurate and precise method cannot be used.
	Volume of Each Type of Fuel used / Vol. Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P10 Thermal Energy Distribution	Volume of Landfill Gas Consumed / Vol. LFG Consumed	m^3	Estimated	Reconciliation of volume of fuel consumed within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

	Methane Composition in LFG / % CH_4	-	Estimated	Interpolation of previous and following measurements taken.	Daily	LFG composition should remain relatively stable during steady-state operation. Interpolating gas composition provides a reasonable estimate when the more accurate and precise method cannot be used.
	Volume of Each Type of Fuel used / Vol. Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P11 Flaring	Volume of Landfill Gas Flared / Vol. LFG Flared	m^3	Estimated	Reconciliation of volume of fuel consumed within given time period based on equipment efficiency specifications and average flow rates.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Methane Composition in LFG / % CH_4	-	Estimated	Interpolation of previous and following measurements taken.	Daily	LFG composition should remain relatively stable during steady-state operation. Interpolating gas composition provides a reasonable estimate when the more accurate and precise method cannot be used.
	Volume of Each Type of Fuel used to Supplement Flare / Vol. Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
Baseline SS's						
B7 Fuel Extraction and Processing	Volume of Fossil Fuel Combusted for B10 / Vol. Fuel	m^3	Estimated	Reconciliation of volume of fuel consumed within given time period based on equipment efficiency specifications and average flow rates.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

B9 Electricity Imported	Incremental Electricity Exported from the Site / Electricity	kWh	Estimated	Reconciliation of power requirements for facility as per equipment output ratings.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B6 Waste Decomposition	Volume of Landfill Gas Consumed / Vol. LFG Consumed	m^3	Estimated	Reconciliation of volume of fuel consumed within given time period based on equipment efficiency specifications and average flow rates.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Methane Composition in LFG / % CH_4	-	Estimated	Interpolation of previous and following measurements taken.	Daily	LFG composition should remain relatively stable during steady-state operation. Interpolating gas composition provides a reasonable estimate when the more accurate and precise method cannot be used.
B10 Offset Fossil Fuel Use	Volume of Each Type of Fuel Offset by Landfill Gas / Vol. $Fuel_i$	m^3	Estimated	Reconciliation of volume of fuel consumed within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.